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(54) **VEHICLE VIDEO SYSTEM**

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H04N 7/18	(2006.01)
B60R 11/04	(2006.01)
B60R 11/00	(2006.01)

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CPC *B60R 1/00* (2013.01); *B60R 11/04* (2013.01); *H04N 7/18* (2013.01); *H04N 7/181* (2013.01); *B60R 2011/004* (2013.01); *B60R 2300/105* (2013.01); *B60R 2300/607* (2013.01); *B60R 2300/802* (2013.01)

(58) **Field of Classification Search**
CPC H04N 7/18
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See application file for complete search history.

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(57) **ABSTRACT**

A method for capturing and displaying images includes a plurality of operations. A first video camera is fixedly attached to a vehicle at a first fixed location in a prescribed orientation relative to a cargo area defined within a vehicle body structure of a vehicle. An electronic display is provided within the vehicle. Video images of the cargo area are captured using the first video camera. The video images of the cargo area captured by the first video camera are processed and a simulated video overhead view of the cargo area is generated. A still image representing an overhead view of the vehicle is displayed on the electronic display, and the generated simulated video overhead view of the cargo area is superimposed on the display over an area of the still image corresponding to the location of the cargo area.

13 Claims, 13 Drawing Sheets
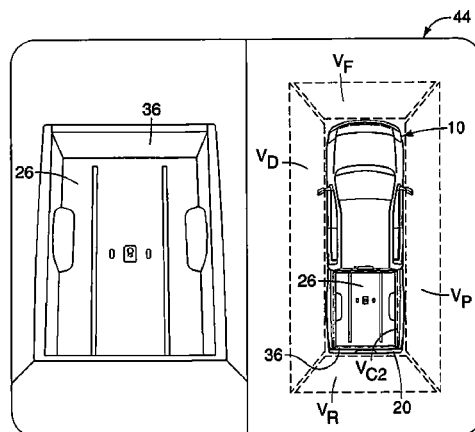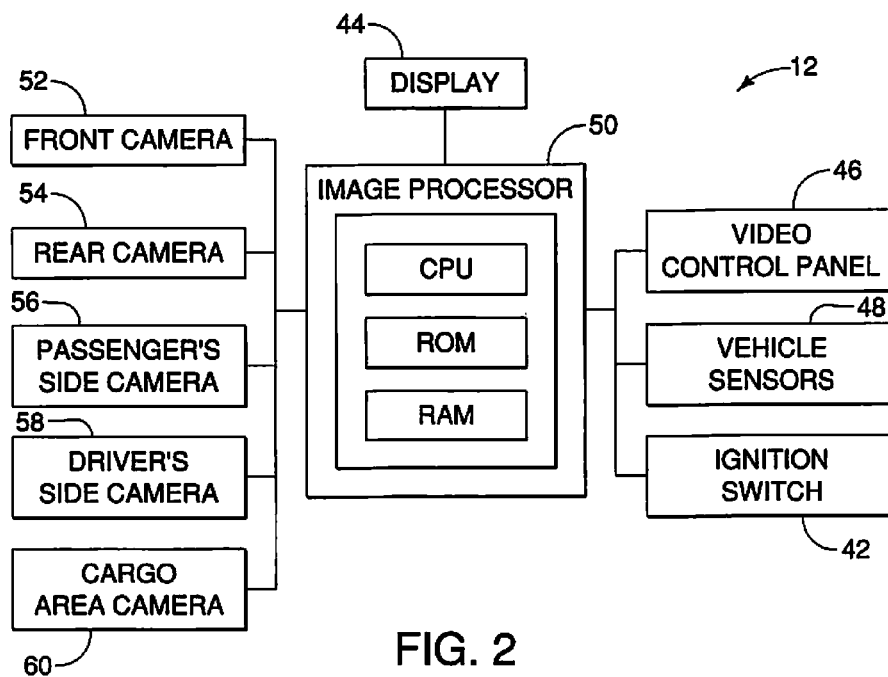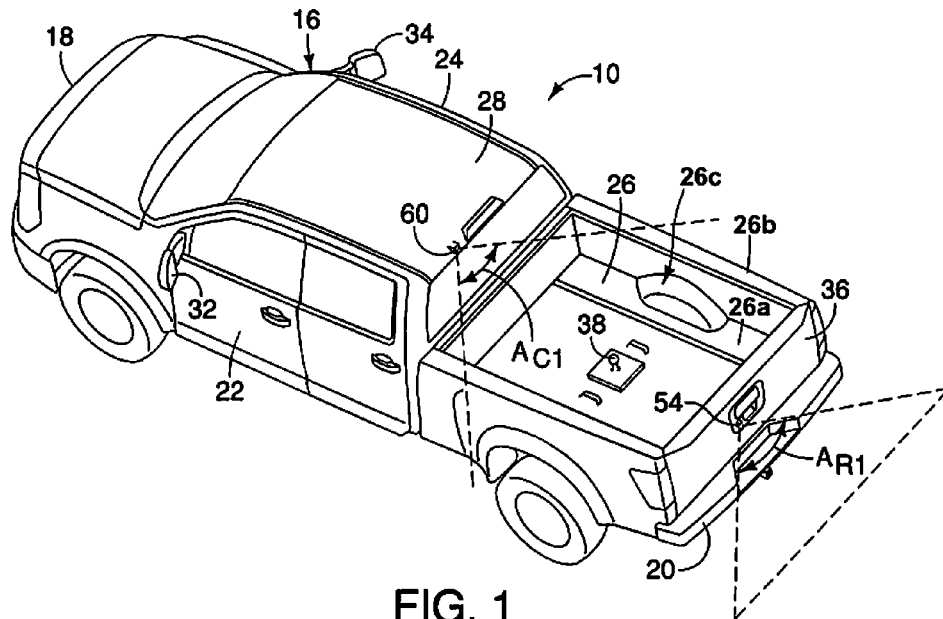
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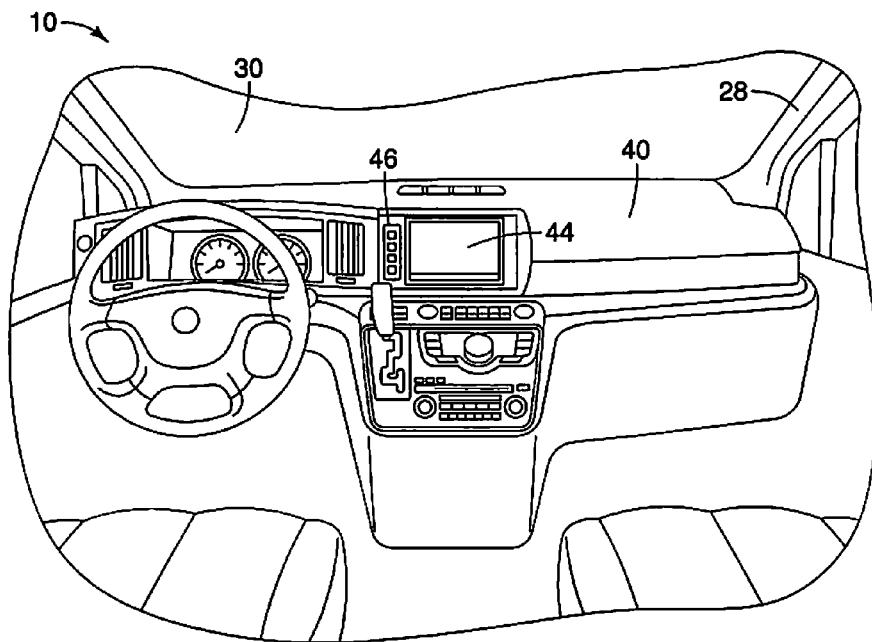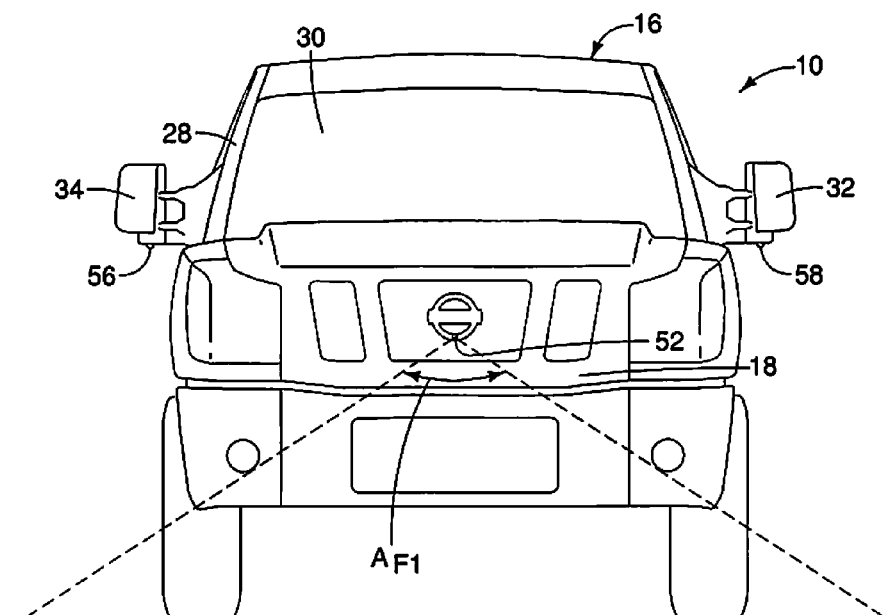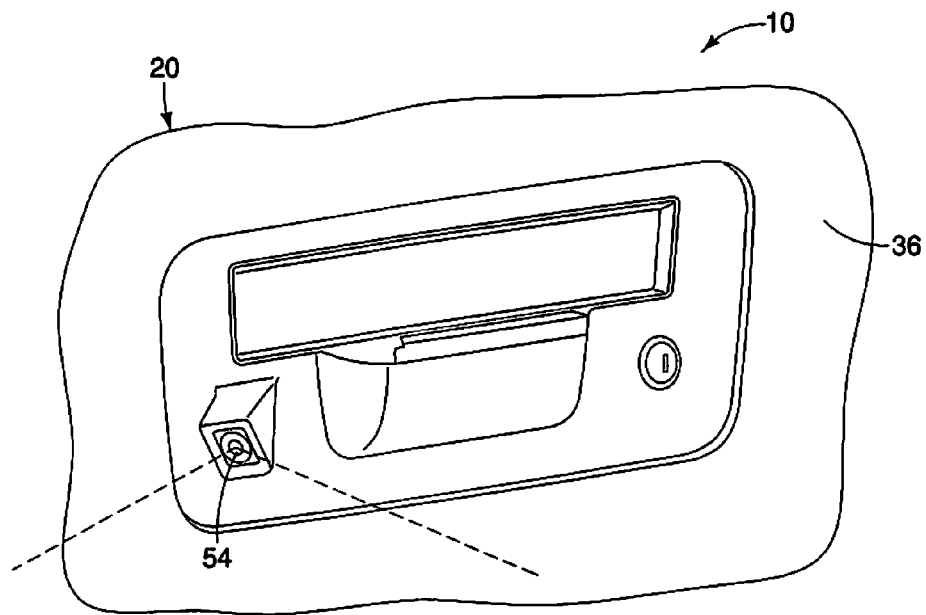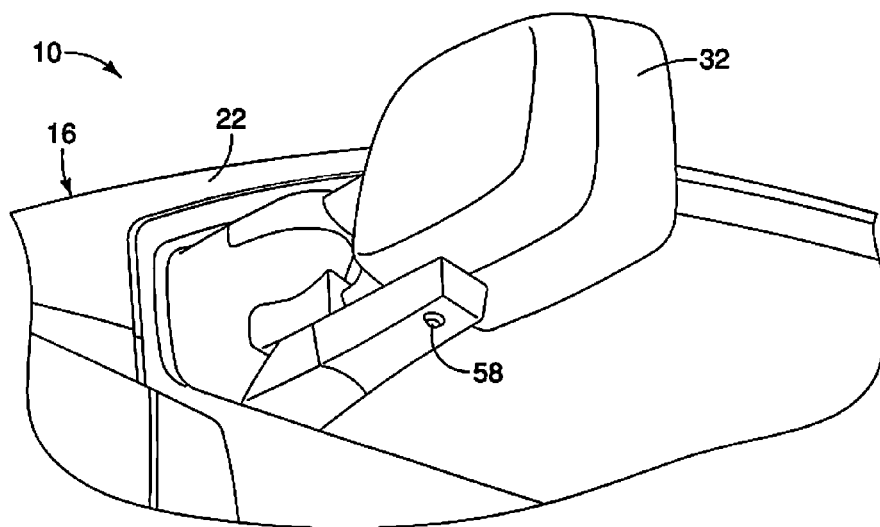|			
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FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5

FIG. 6
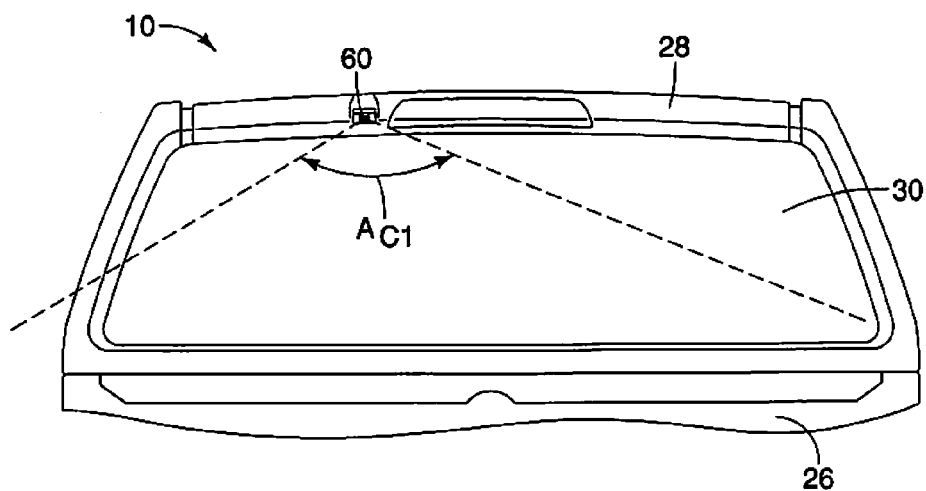
FIG. 7

FIG. 8

FIG. 9

START

S1
SPECIFIC
CAMERA VIEW
REQUESTED?

S2
DISPLAY
REQUESTED
CAMERA VIEW
LEFT SIDE
OF DISPLAY

YES

NO

S3
CARGO
VIEW ONLY
REQUESTED?

YES

S4
GENERATE
SIMULATED
OVERHEAD
VIEW OF
CARGO CAMERA
CAPTURE

NO

S5
SIMULATED
OVERHEAD VIEW
REQUESTED?

NO

YES

S6
IS
REAR CAMERA
OPERABLE?

YES

S7
INCLUDE
REAR CAMERA
CAPTURE

NO

S9
GENERATE SIMULATED
OVERHEAD VIEW USING
EXTENDED CARGO
CAMERA CAPTURE

S8
GENERATE
SIMULATED
OVERHEAD
VIEW USING
REAR CAMERA

RETURN
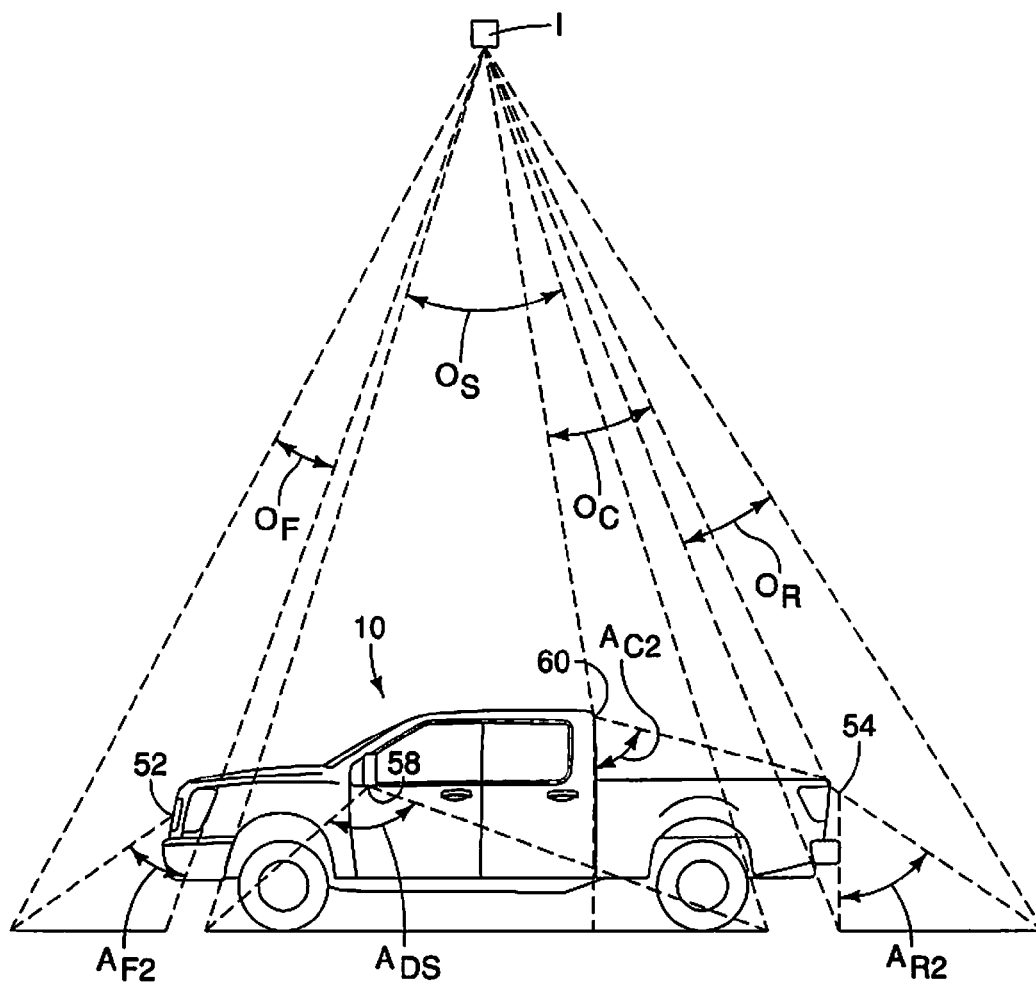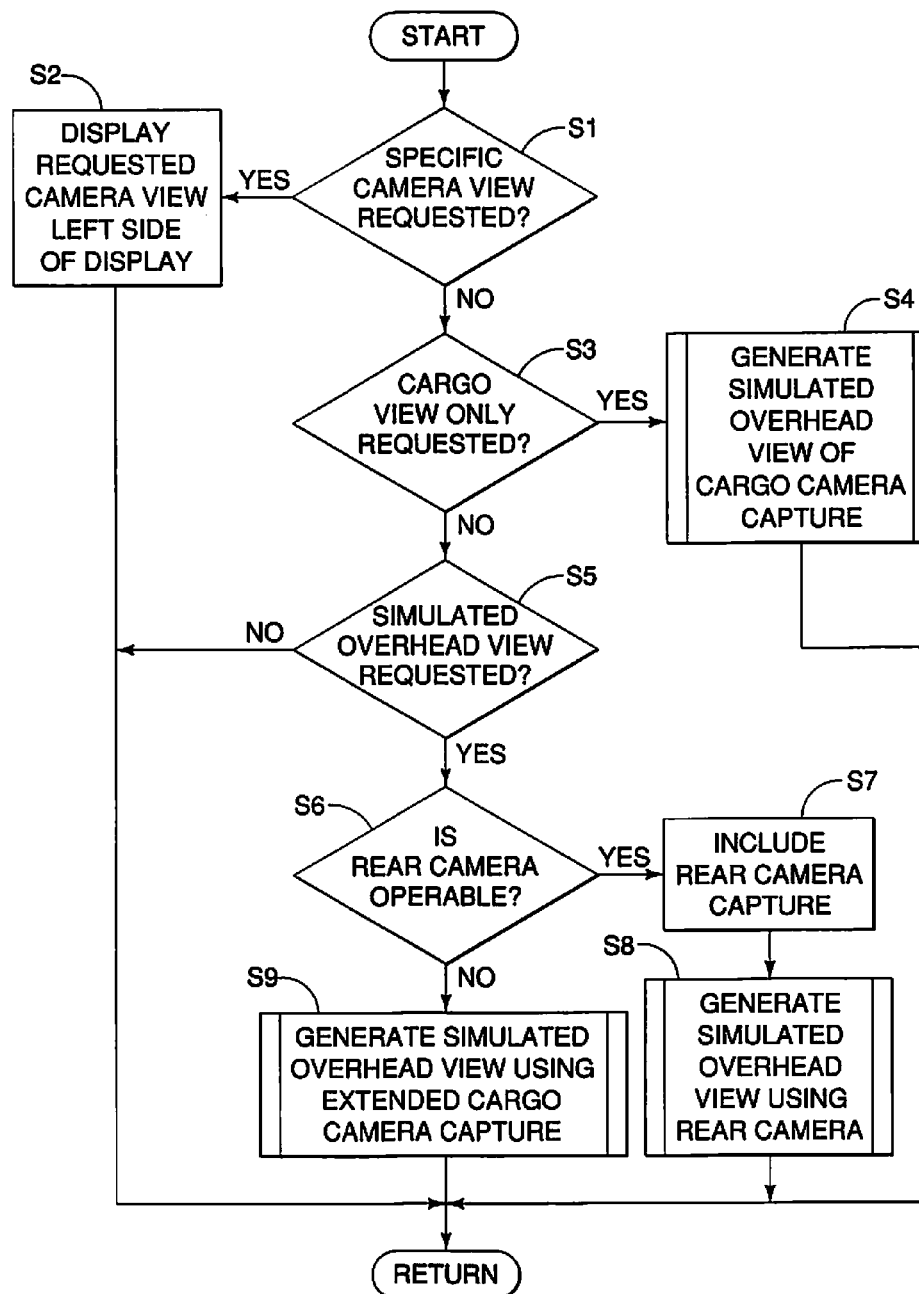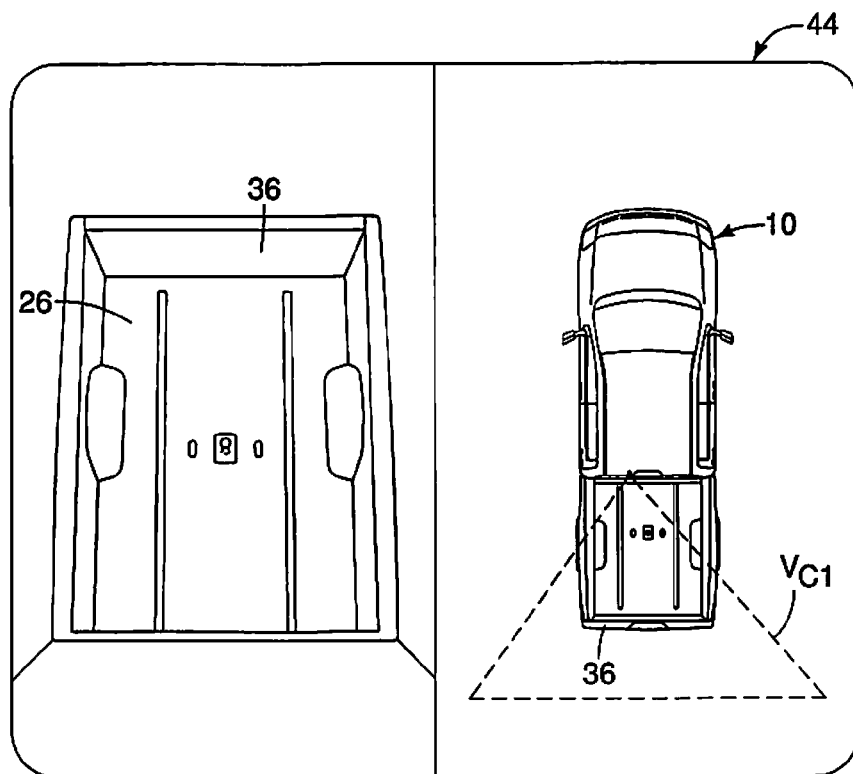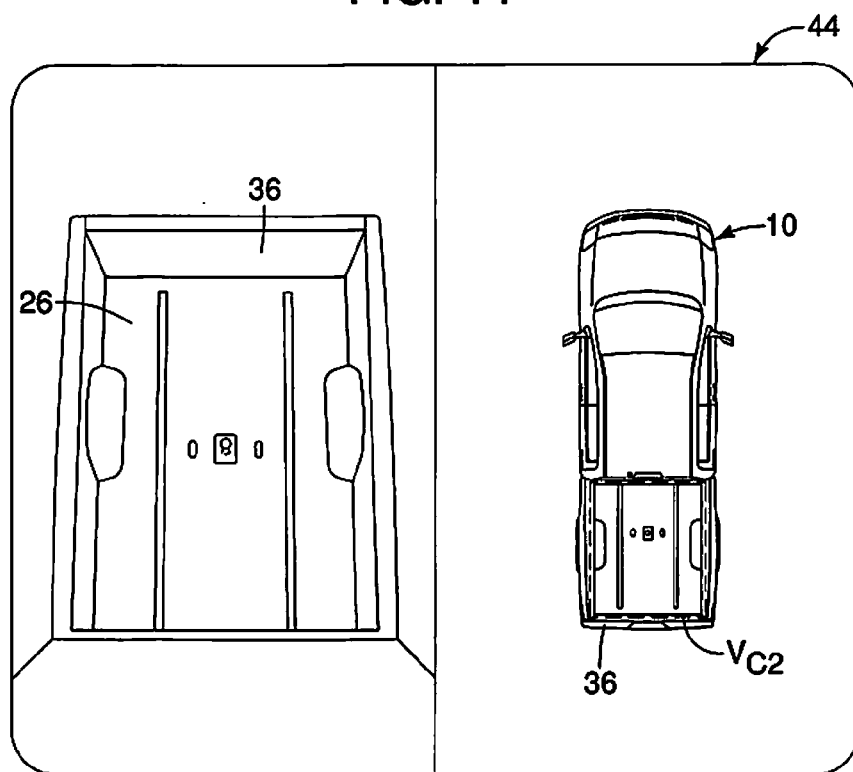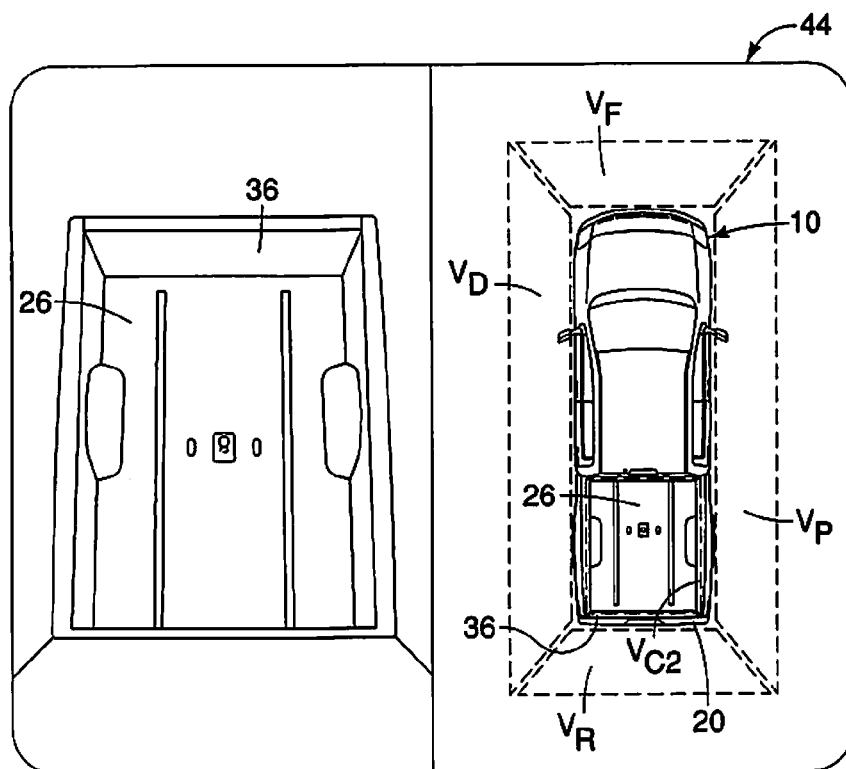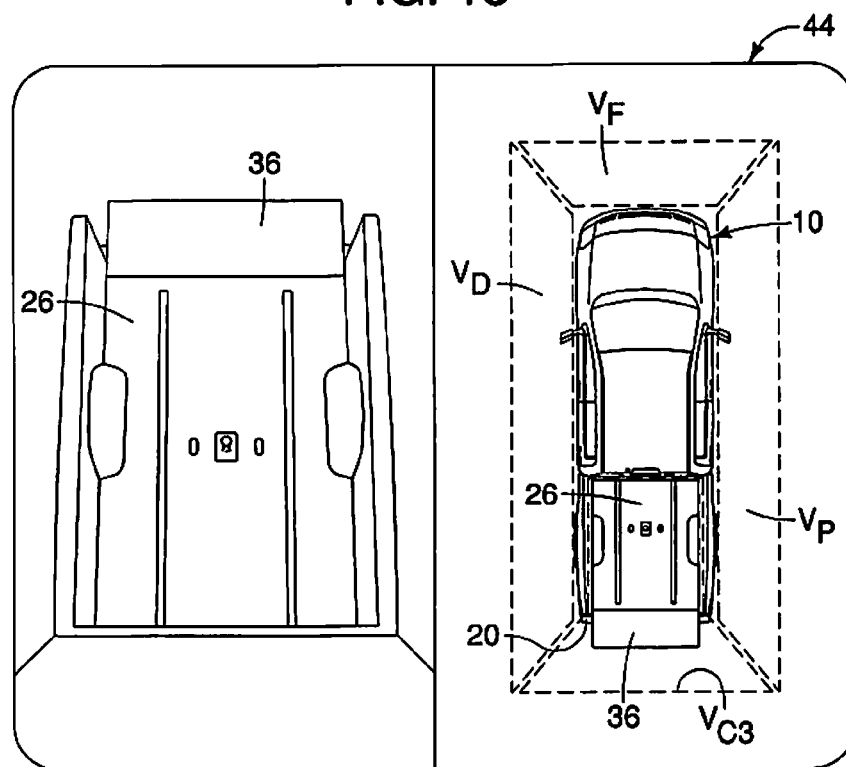
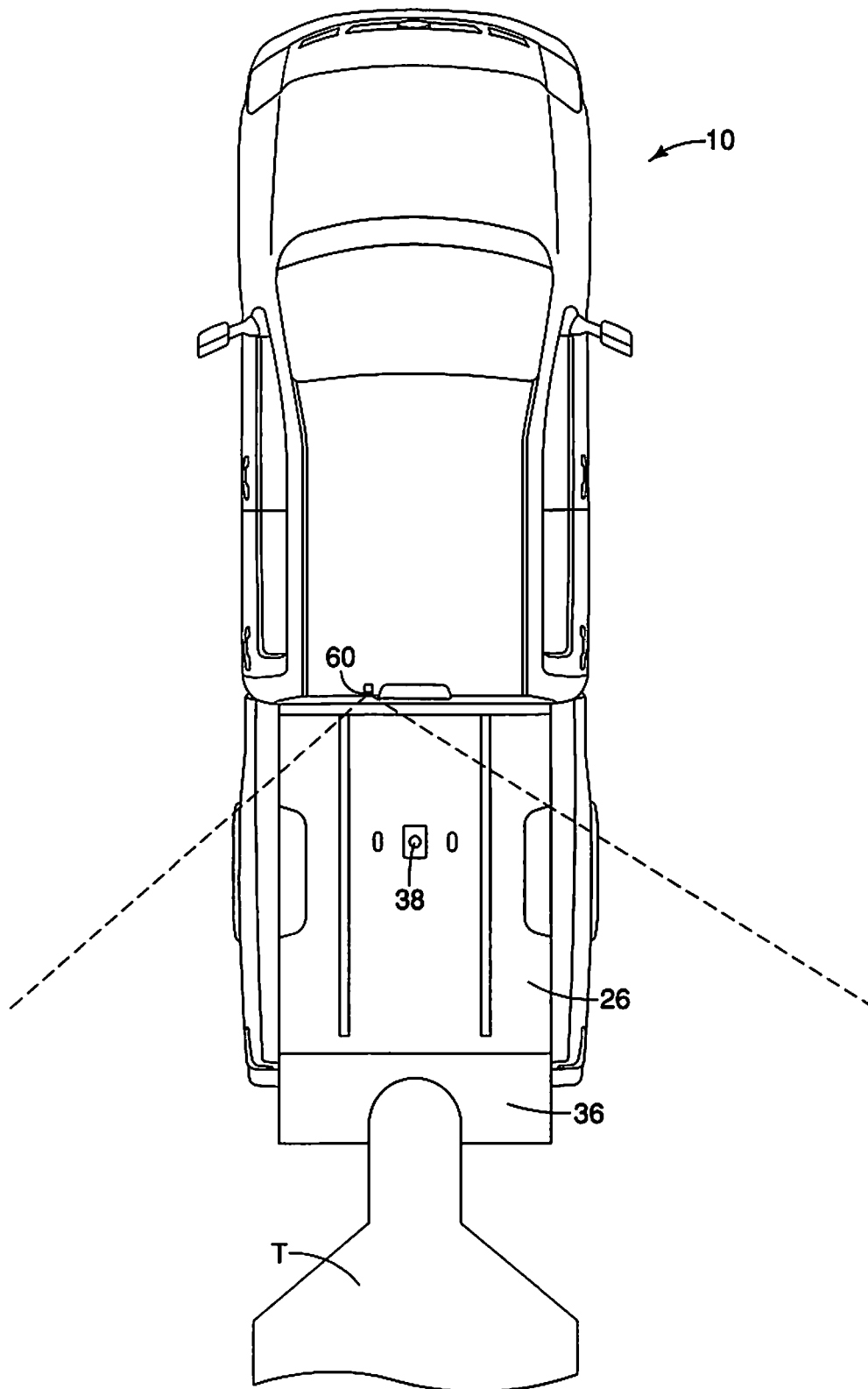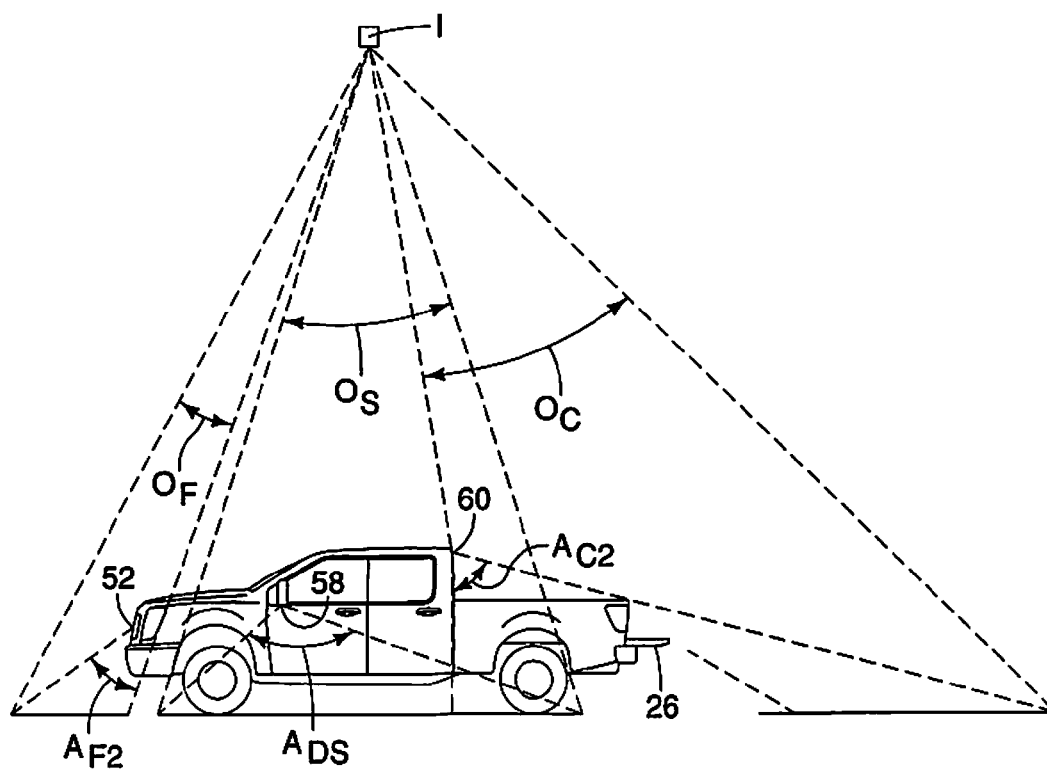FIG. 10

FIG. 11

FIG. 12

FIG. 13

FIG. 14

FIG. 15

FIG. 16

FIG. 17

44'

26c'

26'

26b'   26a'

10'

26'

FIG. 18

10"

30   28

60"   60"

26

FIG. 19

10"

60"   60"

38
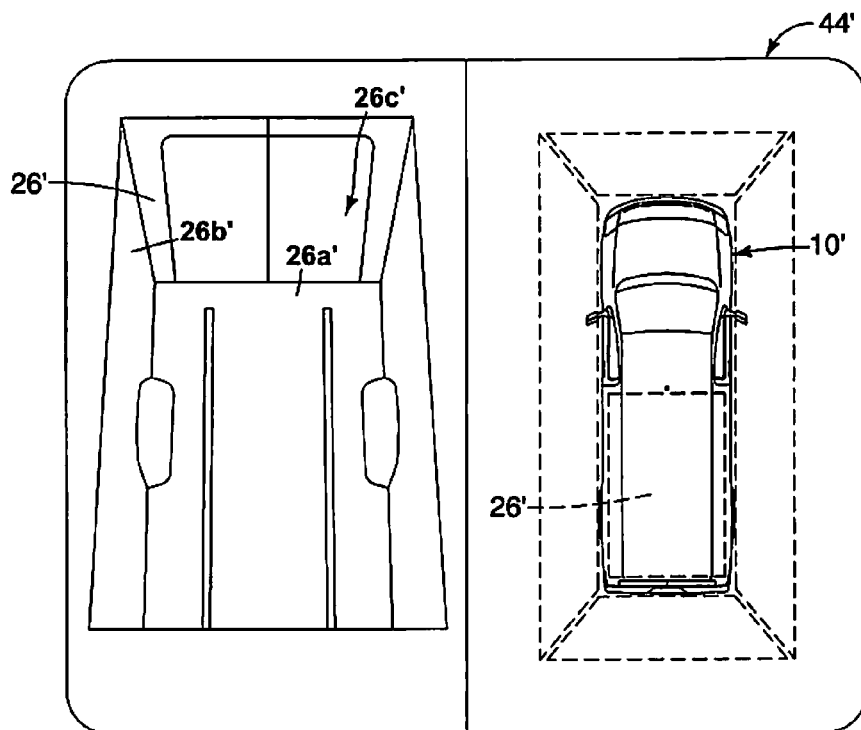
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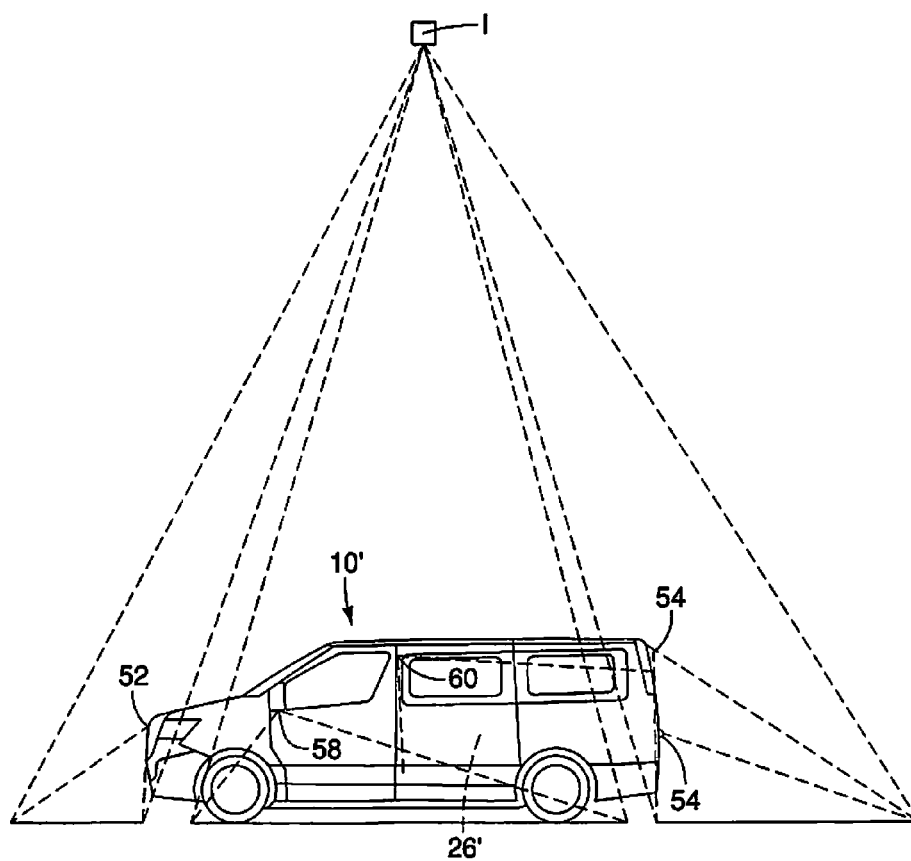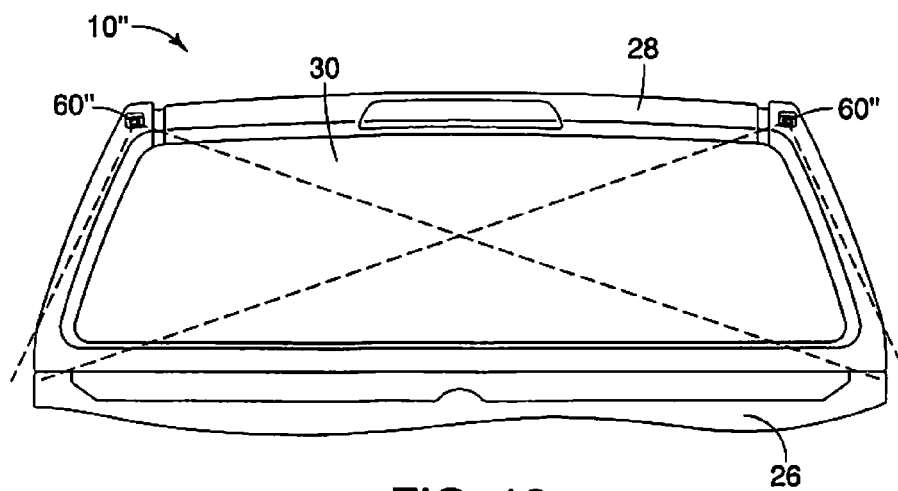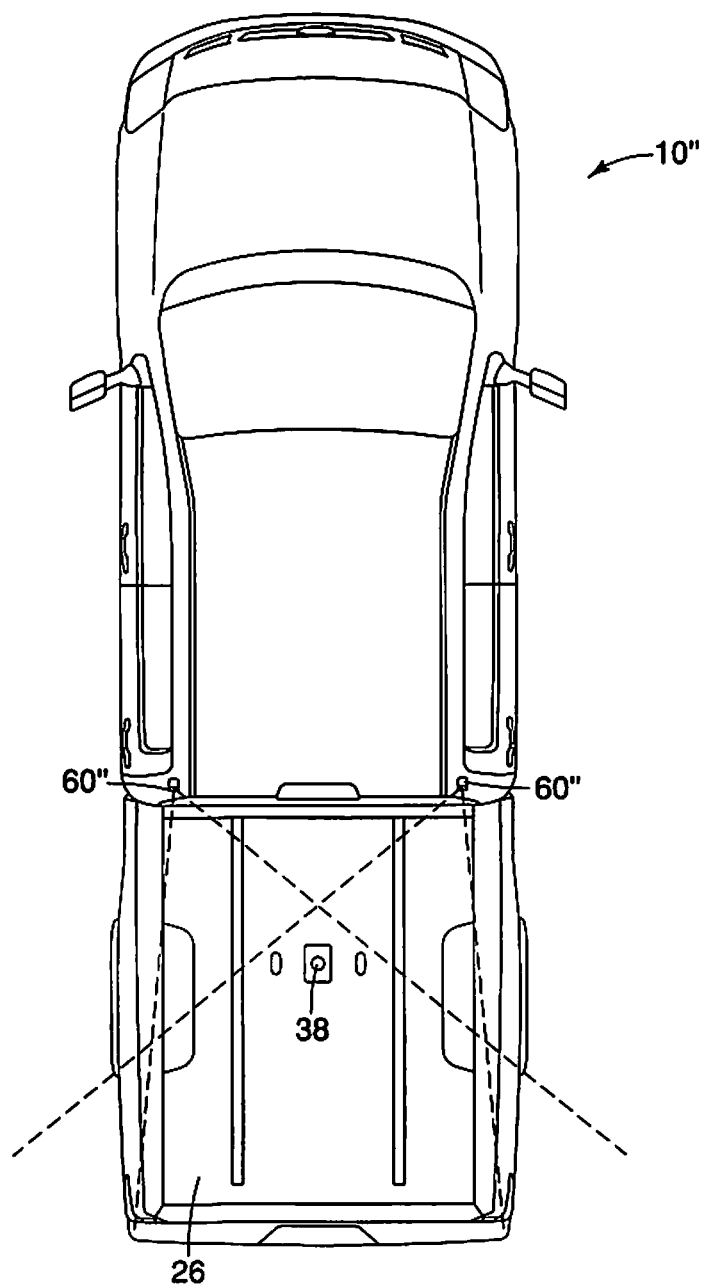
FIG. 20

VEHICLE VIDEO SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation that claims priority under 35 U.S.C. §120 to U.S. application Ser. No. 13/608, 646, filed on Sep. 10, 2012, the entire contents of which are hereby incorporated herein by reference.

BACKGROUND

1. Field of the Invention

The present invention generally relates to a vehicle video system. More specifically, the present invention relates to vehicle video system that includes a camera aimed to capture video images of a cargo area of the vehicle and a system for converting video images captured by the camera into a simulated overhead view of the cargo area.

2. Background Information

Many vehicles have been provided with video cameras, primarily video cameras that provide captured images of areas rearward of the vehicle. One such vehicle includes a display mounted to or installed within an instrument panel of the vehicle, the display showing streaming video images of the areas rearward of the vehicle captured by the video camera. The streaming video images of the areas rearward of the vehicle are displayed in order to assist the driver of the vehicle during the process of parking the vehicle, or for other maneuvers, where the vehicle is moving in reverse (moving backward).

Similarly, a plurality of video cameras have been mounted to a front end and sides of the vehicle such that the driver can observe the streaming video on the display of the images captured by one or all of the plurality of cameras. The plurality of cameras are for the purpose of providing streaming video that the driver can observe while parking the vehicle, to avoid contact with other parked vehicles or stationary objects. Thus, the driver of the vehicle is able to observe movement and/or the location of objects within the areas outside and adjacent to the vehicle as captured by the plurality of cameras.

SUMMARY

One object is to provide a vehicle having a cargo area with a camera that captures video images of the cargo area, with the captured video images being used to generate a simulated overhead view of the cargo area such that the vehicle operator can view a streaming video of the cargo area on a display within the vehicle.

In view of the state of the known technology, in one aspect of the present disclosure, a method for capturing and displaying images, includes fixedly attaching a first video camera to a vehicle at a first fixed location in a prescribed orientation relative to a cargo area defined within a vehicle body structure of a vehicle; providing an electronic display within the vehicle; capturing video images of the cargo area using the first video camera; processing the video images of the cargo area captured by the first video camera and generating a simulated video overhead view of the cargo area; and, displaying on the electronic display a still image representing an overhead view of the vehicle, and superimposing on the display on an area of the still image corresponding to the location of the cargo area the generated simulated video overhead view of the cargo area.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the attached drawings which form a part of this original disclosure:

FIG. **1** is a perspective view of a vehicle that includes a cargo area, the vehicle having a vehicle video system with a camera positioned to capture video of the cargo area in accordance with a first embodiment;

FIG. **2** is a schematic view of the vehicle video system showing a plurality of cameras, including a front camera, a rear camera, a passenger's side camera and a driver's side camera, the cargo area camera, an image processor and a video display in accordance with the first embodiment;

FIG. **3** is a view of a passenger compartment of the vehicle showing the video display of the vehicle video system in an instrument panel in accordance with the first embodiment;

FIG. **4** is a front view of the vehicle showing the position of the front camera of the vehicle video system in accordance with the first embodiment;

FIG. **5** is a perspective view of a rear portion of the vehicle showing the position of the rear camera on a tailgate of the vehicle in accordance with the first embodiment;

FIG. **6** is another perspective view of the vehicle showing the position of the driver's side camera (and indicating the position of the passenger's side camera) on a side view mirror assembly of the vehicle in accordance with the first embodiment;

FIG. **7** is a rear view of a rear portion of a cabin structure of the vehicle showing the position of the cargo area camera in accordance with the first embodiment;

FIG. **8** is another perspective view depicting the rear portion of the cabin structure of the vehicle further showing the position of the rear camera in accordance with the first embodiment;

FIG. **9** is a schematic view of the vehicle showing a virtual or imaginary point above the vehicle pre-programmed into the image processor for generating simulated overhead views of the cargo area and areas around the vehicle (as indicated in FIG. **13**), the image processor using video captured by the cargo area camera, the front camera, the rear camera, the passenger's side camera and the driver's side camera, in accordance with the first embodiment;

FIG. **10** is a flowchart showing operational steps performed by the image processor in accordance with the first embodiment;

FIG. **11** is schematic view of the video display with a split screen, one side (the left side) showing the video captured by the cargo area camera and the other side (the right side) streaming a simulated overhead view streaming at least a portion of the cargo area and areas adjacent to the rear of the vehicle superimposed over a still image of the vehicle in accordance with the first embodiment;

FIG. **12** is another schematic view of the video display with the split screen, one side streaming the video captured by the cargo area camera and the other side streaming a simulated overhead view of the cargo area that is squared off and superimposed over the still image of the vehicle in accordance with the first embodiment;

FIG. **13** is another schematic view of the video display with the split screen, one side streaming the video captured by the cargo area camera and the other side streaming the simulated overhead view of the cargo area and simulated overhead views of each of the areas around the vehicle captured by the front, rear, passenger's side and driver's side cameras, all superimposed over the still image of the vehicle in accordance with the first embodiment;

FIG. **14** is another schematic view of the video display with the split screen, one side streaming the video captured by the cargo area camera with the tailgate down and the other side streaming a simulated overhead view the cargo area and simulated overhead views of each of the areas around the vehicle captured by the front, passenger's side and driver's side cameras, all superimposed over the still image of the vehicle, with an area rearward from the vehicle being captured by the cargo area camera in accordance with the first embodiment;

FIG. **15** is a top view of the vehicle showing an indication of a field of view of the rear camera with the tailgate down, with a trailer rearward of the vehicle and with the vehicle aligning with the trailer in order to connect to the trailer in accordance with the first embodiment;

FIG. **16** is another schematic view of the vehicle showing the imaginary point above the vehicle determined by the image processor for producing the simulated overhead views of the areas around the vehicle as indicated in FIG. **14**, using video captured by the cargo area camera, the front camera, the passenger's side camera and the driver's side camera, with the rear camera being disabled and the cargo area camera capturing video images of the cargo area and an area rearward of the vehicle, in accordance with the first embodiment;

FIG. **17** is a schematic view of a vehicle showing an imaginary point above the vehicle pre-programmed into the image processor for producing simulated overhead views of an internal cargo area of the vehicle and areas around the vehicle as indicated in FIG. **18**, using video captured by a cargo area camera, a front camera, a rear camera, a passenger's side camera and a driver's side camera, in accordance with a second embodiment;

FIG. **18** is a schematic view of a video display with the split screen, one side showing the video captured by the cargo area camera and the other side showing a simulated overhead of view the cargo area and simulated overhead views of each of the areas around the vehicle captured by the front, rear, passenger's side and driver's side cameras, all superimposed over a still image of the vehicle in accordance with the second embodiment;

FIG. **19** is a rear view of a cabin structure portion of a vehicle showing two cargo area cameras in accordance with a third embodiment; and

FIG. **20** is an overhead view of the vehicle showing the approximate areas captured by the two cargo area cameras in accordance with the third embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

Selected embodiments will now be explained with reference to the drawings. It will be apparent to those skilled in the art from this disclosure that the following descriptions of the embodiments are provided for illustration only and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

Referring initially to FIG. **1**, a vehicle **10** is illustrated in accordance with a first embodiment. The vehicle **10** includes a video system **12** depicted schematically in FIG. **2**, and is described in greater detail below.

The vehicle **10** includes a vehicle body **16** with a front end **18**, a rear end **20**, a driver's side **22**, a passenger's side **24**, a cargo area **26** and a cabin structure **28** with a passenger compartment **30** therein. It should be understood that the driver's side **22** and the passenger's side **24** are merely labeled as such with reference to a left-hand drive vehicle and that the functionality of the video system **12** according

to the present invention can be identical in a right-hand drive vehicle. The driver's side **22** includes a driver's side mirror assembly **32**, and the passenger's side **24** includes a passenger's side mirror assembly **34**. The cargo area **26** can include a variety of features, for example, a tailgate **36** and a trailer hitch receiver **38**. As shown in FIG. **1**, the cargo area **26** is a conventional pickup truck structure that includes a floor **26**a and side walls **26**b that define an interior space **26**c that is configured to receive cargo (not shown). An upper area of an interior space **26**c of the cargo area **26** is exposed in a conventional manner. The interior space **25**c of the cargo area **26** is defined between side walls **26**a and the floor **26**b of the cargo area **26**. The tailgate **36** (a movable member) is movable between a closed position (FIG. **1**) confining a rear portion of the interior space **26**c of the cargo area **26** and an open position (indicated in FIGS. **14-16**) providing easy access to the rear portion of the interior space **26**c of the cargo area **26**. The tailgate **36** can also be completely removed from the vehicle **10**.

The passenger compartment **30** includes an instrument panel **40**, as shown in FIG. **3**. The instrument panel **40** includes a variety of features, such as lighting switches, air conditioning controls, radio, an ignition switch **42** (only shown in FIG. **2**), a display **44** and a video control panel **46**.

As shown in FIG. **2**, the video system **12** includes the display **44**, the video control panel **46**, vehicle sensors **48**, an image processor **50**, a front camera **52**, a rear camera **54**, a passenger's side camera **56**, a driver's side camera **58** and a cargo area camera **60**.

In the depicted embodiment of the video system **12**, there are five cameras, the front camera **52**, the rear camera **54**, the passenger's side camera **56**, the driver's side camera **58** and the cargo area camera **60**. However, it should be understood from the drawings and the description herein that the number of cameras installed to the vehicle **10** can be varied. For example, in one embodiment, the vehicle **10** can be provided with just one camera (e.g., the cargo area camera **60**), multiple cargo area cameras, and/or the plurality of video cameras depicted schematically in FIG. **2** capturing video images of the area around the periphery of the vehicle **10**, as described below.

In the description of the video system **12**, several terms are used in a manner consistent with the definitions provided below.

Specifically, the terms "video", "video image" or "video images" as used herein refer to a series of captured images showing current movement or lack of movement in a predetermined area captured by each respective one of the plurality of cameras including the cargo area camera **60**.

The term "simulated live overhead view" as used herein refers to a video image of an area that is captured by one or more cameras that are not physically oriented capture a literal top plan view of the area. Rather, the captured video images are processed to generate or form an appearance of a top plan view of the corresponding area.

The terms "stream", "streaming", "streaming video", or other similar forms as used herein include storing the video image in a storage device (e.g. RAM, hard drive, FLASH memory, etc.,) prior to displaying. However, preferably, the streaming has only a prescribed amount of latency (125 milliseconds delay or less—125 milliseconds is ⅛th of a second) between the moment of capture and the moment the video image or video images are displayed on the display **44**.

As is described in greater detail below, the display **44** is configured to display a variety of video images in the form of streaming video. Specifically, the display **44** receives processed video data from the image processor **50** based

5

6

upon video images captured by one, selected ones or all of the plurality of cameras of the video system **12** depicted in FIG. **2**. The display **44** can be configured in any of a variety of ways. For example, the display **44** can display: streaming video from just one selected camera at a time; streaming video from all of the cameras; or a simulated overhead view where some or all of the captured video images are manipulated by the image processor **50** and then superimposed over a still image of the vehicle **10**, to produce the simulated overhead view of the vehicle **10** and surrounding areas on all sides of the vehicle **10**, as is described in greater detail below. In the depicted embodiments, the display **44** is also configured to provide a split screen where half of the viewing area of the display **44** shows the actual streaming video images from the selected camera and the other half of the display **44** shows a selected overhead simulated view of the vehicle **10** and the areas around the vehicle **10**.

The video control panel **46** in the instrument panel **40** is provided with one or more controls that allow an occupant of the vehicle **10** to select the type of view desired for output on the display **44**. For example, the video control panel **46** can be provided with quick glance buttons or inputs (not shown) that cause the image processor **50** to stream captured images from a specific one of the plurality of cameras for just a short, predetermined period of time. One example of such a quick glance button includes a request to stream the captured video from the passenger's side camera **38** for ten (10) to fifteen (15) seconds to the display **44** so that the driver monitor the status of objects within the field of view of the passenger's side camera **38**. Another example of a quick glance button includes a request to stream the captured video from the cargo area camera **60** for ten (10) seconds to fifteen (15) seconds so that the driver monitor the status of objects in the cargo area **26**. Other features of the video system **12** are explained in greater detail below.

The vehicle sensors **48** vary from vehicle to vehicle. The vehicle sensors **48** can be a single sensor or an array of sensors. However in the depicted embodiment, the vehicle sensors **48** can include a vehicle speed sensor (not shown), a transmission sensor (not shown) and a tailgate position sensor within the tailgate **36** or at the rear end **20** of the vehicle **10**. The speed sensor provides vehicle speed information to the image processor **50** such that, below a prescribed speed, the image processor automatically sets the display **44** to, for example, display a video image captured by a predetermined one of the cameras, or alternatively, can shut off the display **44** during high speed operation of the vehicle **10** (e.g., above speeds typically associated with parking procedures). The transmission sensor can be configured to provide the image processor **50** with the status of the transmission of the vehicle **10**. For example, when the transmission is set in reverse such that the vehicle **10** is capable of moving rearward, the video image captured by the rear camera **54** can be automatically displayed on the display **44**. The tailgate position sensor provides an indication of the position of the tailgate **36**. As is described in greater detail below, when the tailgate **36** is in an open position, the performance of the rear camera **54** may be compromised. The tailgate position sensor of the plurality of sensors **48** provides the image processor **50** with an indication of the status of the rear camera **54**.

The image processor **50** is configured to process the various video images captured by the plurality of cameras **52**, **54**, **56**, **58** and **60** in a manner described in greater detail below. The image processor **50** preferably includes a microcomputer (i.e., a central processing unit or CPU) with a video processing control program that processes streaming

video output to the display **44**. The image processor **50** can also include other conventional components such as an input interface circuit, an output interface circuit, and storage devices such as a ROM (Read Only Memory) device and a RAM (Random Access Memory) device. The microcomputer of the image processor **50** is programmed to process the video images from the plurality of cameras in order to generate simulated overhead views of the areas captured by each of the plurality of cameras, as is described in greater detail below. The memory circuit stores processing results and control programs such as ones for video processing operations that are run by the image processor **50**. The image processor **50** is operatively coupled to the plurality of cameras and the display **44** in a conventional manner, such as by coaxial cables, computer cables, wireless connections or other similar configurations capable of transferring video images or video data from one location to another within a vehicle. The internal RAM of the image processor **50** stores statuses of operational flags and various control data. The internal ROM of the image processor **50** stores image data and transformational data for various operations. The image processor **50** is capable of selectively controlling any of the components of the video system **12** in accordance with the control program. It will be apparent to those skilled in the art from this disclosure that the precise structure and algorithms for the image processor **50** can be any combination of hardware and software that will carry out the functions of the present invention.

It should also be understood from the drawings and the description herein that the image processor **50** can be programmed to stream any of a variety of combinations of video images to the display **44**. The depictions of the display **44** and its streamed content shown in FIGS. **11-14** are some examples of the types of streamed video images that can be shown in the display **44**. However, the present invention is not limited to the examples of streamed video images shown on the display **44** in FIGS. **11-14**. The display **44** can show a full screen video image or multiple split screen configurations depending upon the pre-programming and configuration of the image processor **50**.

A description of the plurality of cameras is now provided with respect to FIGS. **1** and **4-8**. As shown in FIG. **4**, the front camera **52** is fixedly attached to the vehicle body **16** at the front end **18** of the vehicle **10**. In the depicted embodiment, the front camera **52** is fixedly attached to an emblem of the front grille at the front end **18** of the vehicle **10**. The front camera **52** is fixed in position relative to the front end **18** such that the front camera **52** captures video of the area frontward of the front end **18** of the vehicle **10**. The front camera **52** is aimed downwardly, but is angled relative to vertical so that the front camera **52** is aimed at the area frontward of the front end **18** of the vehicle **10**. The angle A_{F1} in FIG. **4** provides an approximate frontal indication of the field of view captured by the front camera **52**. The angle A_{F2} in FIG. **9** shows an approximate side indication of the field of view captured by the front camera **52**.

As shown in FIGS. **1** and **5**, the rear camera **54** is fixedly attached the tailgate **36** at the rear end **20** of the vehicle **10**. In the depicted embodiment, the rear camera **54** is fixed to a plate or housing of the latch release handle of the tailgate **36**. The rear camera **54** is fixed in position relative to the tailgate **36** such that the rear camera **54** captures the area rearward of the rear end **20** of the vehicle **10**. With the tailgate **36** in the closed position, the rear camera **54** is aimed downwardly, but is angled relative to vertical so that the rear camera **54** is aimed at the area rearward of the rear end **20** of the vehicle **10**. The angle A_{R1} in FIG. **1** provides an

approximate indication of the side-to-side field of view captured by the rear camera 54. The angle A_{R2} in FIG. 9 shows an approximate side indication of the rearward field of view captured by the rear camera 54.

As shown in FIG. 6, the driver's side camera 58 is fixedly attached an underside of the driver's side mirror assembly 32 at the driver's side 22 of the vehicle 10. The passenger's side camera 56 is similarly attached to an underside of the passenger's side mirror assembly 34. The driver's side camera 58 is fixed in position relative to the driver's side mirror assembly 32 with the driver's door closed such that the driver's side camera 58 captures the area along the side of the driver's side 22 of the vehicle 10. The angle ADS in FIG. 9 provides an approximate indication of the field of view captured by the driver's side camera 58.

Since the passenger's side camera 56 is symmetrically installed to the passenger's side mirror assembly 34 in a manner consistent with the driver's side camera 58, further description of the passenger's side camera 56 is omitted for the sake of brevity.

As shown in FIGS. 1, 7 and 8, the cargo area camera 60 is fixedly attached the rearward end of the roof of the cabin structure 30 of the vehicle 10. The cargo area camera 60 is fixed in position relative to the cabin structure 28 such that the cargo area camera 60 captures the cargo area 26 and areas rearward of the rear end 20 of the vehicle 10 when the tailgate 36 is in the down or open position. The cargo area camera 60 is aimed downwardly, but is angled relative to vertical so that the cargo area camera 60 is aimed primarily at the cargo area 26, but as is described further below, the cargo area camera 60 can also capture the area rearward of the rear end 20 of the vehicle 10 with the tailgate 36 in the open position. The angle A_{C1} in FIGS. 1 and 7 provides an approximate indication of the side-to-side field of view captured by the cargo area camera 60. The angle A_{C2} in FIG. 9 provides an approximate side indication of the rearward field of view captured by the cargo area camera 60.

Each of the plurality of cameras (the front camera 52, the rear camera 54, the passenger's side camera 56, the driver's side camera 58 and the cargo area camera 60) are installed at predetermined, fixed locations relative to the vehicle body 16. These predetermined, fixed locations are used by the image processor 50 such that a simulated overhead view is generated, as described below. As is explained in greater detail below, the generation of each of the simulated overhead views from the images captured by each of the plurality of cameras requires that the position of each camera relative to the vehicle body 16 be fixed. For the rear camera 54, the fixed position is predetermined with the tailgate 36 in the closed position. For the passenger's side camera 56 and the driver's side camera 58, the respective fixed positions are predetermined with the passenger and driver doors in their respective closed positions.

Hence, the cargo area camera 60 is fixedly mounted to the vehicle 10 at the rear portion of the roof of the cabin structure 28, which is a fixed location relative to the vehicle 10. Further, the cargo area camera 60 is fixed in a prescribed orientation relative to the vehicle 10 to capture video images of the cargo area 26, as indicated in 1, 7 and 9.

A description of the image processor 50 and its operation is now provided with reference to FIGS. 9 through 16. As mentioned above, the image processor 50 is configured to receive the video images captured by any one and/or all of the plurality of cameras and stream them to the display 44 such that the driver of the vehicle 10 can look at the display 44 and observe the streaming video. The image processor 50 is also configured to: receive the video images captured by

any one and/or all of the plurality of cameras; process each of the images thereby producing simulated overhead views of the area captured by a selected one and/or all of the plurality of cameras; and stream the simulated overhead view or views to the display 44, overlaying the simulated views over a still image of the vehicle 10, such that the driver of the vehicle 10 can look at the display 44 and observe streaming video of the simulated overhead view or views.

FIG. 9 shows a side view of the vehicle 10 showing the front camera 52, the rear camera 54, the driver's side camera 58 and the cargo area camera 60. It should be understood that the passenger's side camera 56 is symmetrically placed on the passenger's side 24 of the vehicle 10, opposite from the driver's side 22 of the vehicle 10, and therefore captures an area along the side of the vehicle 10 opposite from the driver's side camera 58.

In FIG. 9, the angle A_{F2} shows the indication of the field of view captured by the front camera 52, the angle A_{R2} shows the indication of the field of view captured by the rear camera 54, the angle ADS shows the indication of the field of view captured by the driver's side camera 58 and the angle A_{C2} shows the indication of the field of view captured by the cargo area camera 60. As indicated above, the passenger's side camera 56 captures a field of view similar to that of the driver's side camera 58. The image processor 50 receives the video images from each of the plurality of cameras and processes them to produce corresponding overhead simulated views, with a virtual or imaginary view point I, also shown in FIG. 9.

In other words, the image processor 50 includes programming that takes the video images captured within the field of view corresponding to angle A_{F2} by the front camera 52 and produces an overhead view V_F as shown at the right side of the display 44 in FIGS. 13 and 14. The overhead view V_F is generated by the image processor 50 to make it appear that the overhead view V_F is actually captured from the imaginary view point I with a field of view corresponding to the overhead angle O_F shown in FIG. 9.

Similarly, the image processor 50 takes the video images captured within the field of view corresponding to angle A_{R2} by the rear camera 54 and produces an overhead view V_R as shown at the right side of the display 44 in FIG. 13. The overhead view V_R is generated by the image processor 50 to make it appear that the overhead view V_R is actually captured from the imaginary view point I with a field of view corresponding to the overhead angle O_R shown in FIG. 9.

Further, the image processor 50 takes the video images captured within the field of view corresponding to angle ADS by the driver's side camera 58 (and similarly from the passenger's side camera 56) and produces an overhead view V_D (and overhead view V_P) as shown at the right side of the display 44 in FIGS. 13 and 14. The overhead view V_D (and overhead view V_P) is generated by the image processor 50 to make it appear that the overhead view V_D (and overhead view V_P) is actually captured from the imaginary view point I with a field of view corresponding to the overhead angle O_S shown in FIG. 9.

The image processor 50 is further configured to process video images captured by the cargo area camera 60 in any of a variety of manners. Specifically, the image processor 50 can process the video images captured by the cargo area camera 60 to generate an unaltered streaming video of a view of the cargo area 26, as shown on the left side of the display 44 in each of FIGS. 11-14. The image processor 50 also processes the video images captured by the cargo area camera 60 to generate a first overhead image V_{C1} of the

cargo area **26** and limited areas rearward and to either rearward side of the vehicle **10** with the tailgate **36** in the closed position, as shown on the right side of the display **44** in FIG. **11**. The image processor **50** can also process the video images captured by the cargo area camera **60** to generate a second overhead image V_{C2} of the cargo area **26** as shown on the right side of the display **44** in FIGS. **12** and **13**.

As well, the image processor **50** takes the video images captured within the field of view corresponding to angle A_{C2} by the cargo area camera **60** and produces an overhead view V_{C3} as shown on the right side of the display **44** in FIG. **14**, which includes the cargo area **26** and areas rearward from the vehicle **10** with the tailgate **36** in the open position. The overhead views V_{C1}, V_{C2} and V_{C3} are generated by the image processor **50** to make it appear that the overhead view V_{R} is actually captured from the imaginary view point I with a field of view corresponding to the overhead angle O_{R} shown in FIG. **9**. The driver of the vehicle **10** can select which of the overhead views V_{C1}, V_{C2} and V_{C3} are to be streamed to the display by manually operating the video control panel **46**.

The image processor **50** generates the various overhead views using any of a variety of algorithms. For example, in one embodiment, the image processor **50** is pre-programmed to include three dimensional coordinates relative to the vehicle body **16**, of the predetermined locations of each of the front camera **52**, the rear camera **54**, the passenger's side camera **56**, the driver's side camera **58** and the cargo area camera **60**. The planar coordinates of the field of view of each of the plurality of cameras using an assumed level or generally flat ground under the vehicle **10** as a reference relative to the vehicle **10** are also pre-programmed or stored in the image processor **50**. These three dimensional relationships are used to construct a conversion table (not shown) that is used by the image processor **50** to manipulate the captured images to generate the simulated overhead view V_{F}, V_{D}, V_{P}, V_{R} and V_{C3}.

Since the predetermined locations of the plurality of cameras are fixed relative to the overall structure of the vehicle body **16**, the processing work done by the image processor **50** is conducted using fixed coordinates or fixed reference points relative to the vehicle body **16**. Specifically, the ground under the vehicle **10** is assumed to be flat providing a planar frame of reference and the plurality of cameras are at fixed locations relative to the vehicle body **16** and the ground under the vehicle **10**. The image processor **50** is therefore provided with the three dimensional relative distances and three dimensional relative coordinates between the ground under the vehicle **10** and each of the plurality of cameras relative to the vehicle **10**.

The image processor **50** carries out a coordinate conversion of each of the sets of video images captured by the front camera **52**, the rear camera **54**, the passenger's side camera **56**, the driver's side camera **58** and the cargo area camera **60** using the known predetermined locations of the plurality of cameras, the areas relative to the vehicle **10** that each camera views and the imaginary view point I, and synthesizes or generates the simulated overhead views V_{F}, V_{D}, V_{P}, V_{R} and V_{C3} and superimposes them on the still image of the vehicle **10**, as shown on the right side of the display **44** in FIG. **13**.

The vehicle surroundings or areas around the vehicle **10** captured by the plurality of cameras, and the cargo within the cargo area **26** are included in the video images processed by the image processor **50**. The image processor **50** can also process the video images of objects in the cargo area **26** and in the areas surrounding the vehicle **10** by using a relation between pixel addresses of the images before and after the conversion. Specifically, the image processor **50** carries out a viewpoint conversion (of the respective images of vehicle surroundings taken by the plurality of cameras) to the simulated overhead views. Then, after the viewpoint conversion, the image processor **50** joins the video images of the vehicle surroundings. With this, the image processor **50** converts the video images of the vehicle surroundings to the overhead view images (looking down the image-taking area from directly overhead at the center of the vehicle).

More detailed descriptions of various processes used to generate overhead simulated views can be found in, for example, U.S. Patent Application Publication No. 2010/0238051, published Sep. 23, 2010 (application Ser. No. 12/680,423), U.S. Patent Application Publication No. 2012/0069182, published Mar. 22, 2012 (application Ser. No. 13/232,146), and U.S. Pat. No. 8,243,994, issued Aug. 14, 2012 (application Ser. No. 12/298,837) all commonly assigned to Nissan Motor Co. Ltd. The disclosures of U.S. Patent Application Publication No. 2010/0238051, U.S. Patent Application Publication No. 2012/0069182, and U.S. Pat. No. 8,243,994 are incorporated herein by reference in their entirety.

A description of the basic operations of the image processor **50** is now provided with respect to the flowchart in FIG. **10**. The video system **12** starts up when the ignition switch **42** is turned on. Further, if the ignition switch **42** is not on, the video system **12** is disabled or turned off. The ignition switch **42** can be a keyless switch or a switch that requires a key, depending upon the specific vehicle design. Once the ignition switch **42** is turned on, operation moves to step S1 where the image processor **50** waits for instructions or view requests inputted by an occupant or driver of the vehicle **10**.

At step S1, a determination is made by the image processor **50** whether or not the driver or an occupant of the vehicle **10** has inputted to the video control panel **46** (a controller) a request for the video images from a specific camera to be streamed to the display **44**. If such a request has been inputted, the image processor **50** streams the selected captured video images to the left side of the display **44**.

Included in the processing at step S1 is also detection based on signals from the vehicle sensors **48**, and a determination whether or not the transmission of the vehicle is set in reverse gear indicating that the driver is backing up the vehicle **10**. If the transmission is in reverse, the image processor **50** interprets that information as a request for an unaltered streaming of the area rearward of the vehicle **10** captured by the rear camera **54** (or captured by the cargo area camera **60** if the rear camera **54** is disabled). As a result, the image processor **50** streams to the left side of the display **44** unaltered video images captured by the rear camera **54** (or captured by the cargo area camera **60**).

At step S2, the video images from the selected one of the plurality of cameras streamed by image processor **50** to the left side of the display **44**. In the depicted examples shown in FIGS. **11-14**, the selected one of the plurality of cameras is the cargo area camera **60**. Thus, in each of the examples in FIGS. **11-14**, the image processor **50** streams the video images from the cargo area camera **60** to left side of the display **44**.

From step S2, operations return back to the top of the flowchart in FIG. **10**, and consequently step S1 is repeated. If no further requests are made (if there is no change in the requested camera), operation moves to step S3. At step S3, the image processor **50** determines whether or not the video control panel **46** has received a request for a simulated

overhead view of only the cargo area, and which type of simulated overhead view has been requested. If the image processor **50** determines that such a request has been made at step S3, then operation moves to step S4 where the image processor **50** streams one of the overhead simulated views of the cargo area **26** to the right side of the display **44**. Specifically, the image processor **50** can stream the simulated overhead view V_{C1} to the right side of the display **44**, as indicated in FIG. **11**. As shown in FIG. **11**, the simulated overhead view V_{C1} includes a wide angle view of the cargo area **26** and areas rearward from the rear end **20** of the vehicle **10**. Alternatively, if requested by the driver or occupant, the image processor **50** can stream the simulated overhead view V_{C2} to the right side of the display **44**, as indicated in FIG. **12**. As shown in FIG. **12**, the simulated overhead view V_{C2} includes only a simulated overhead view of the cargo area **26**.

At step S3, if a request for not only the cargo area has been made, operation moves to step S5. At step S5, a determination is made as to whether or not a composite simulated overhead view has been requested. If a composite view has been requested, then operation then moves to step S6. At step S6, the image processor **50** determines whether or not the rear camera **54** is operable or not, for example, by receiving a signal from the tailgate sensor of the vehicle sensors **48**. For example, if the tailgate **36** is in the closed position (FIG. **13**), then the rear camera **54** is operable. If the tailgate **36** is down or in the open position (FIG. **14**), then the rear camera **54** is not operable. Further, if the tailgate **36** has been removed from the vehicle **10**, then the rear camera **54** is not operable.

Once a determination has been made at step S6, if the rear camera **54** is operable, operation moves to step S7. If the rear camera **54** is not operable, operation moves to step S9, described below.

At step S7, since the rear camera **54** is operable, the video images captured by the rear camera **54** are processed by the image processor **50**, along with the images captured by the front camera **52**, the passenger's side camera **56**, the driver's side camera **58** and the cargo area camera **60** and operation moves to step S8. At step S8, the image processor **50** generates the simulated overhead views V_F, V_R, V_D, V_P and V_{C2}, and overlays them on a still image of the vehicle **10**, as shown at the right side of the display **44** in FIG. **13**.

If at step S6, the image processor determines that the rear camera **54** is not operable, operation moves to step S9. At step S9, the video images captured by the front camera **52**, the passenger's side camera **56**, the driver's side camera **58** and the cargo area camera **60** are processed and the image processor **50** generates the simulated overhead views V_F, V_D, V_P and V_{C3}, and overlays them on a still image of the vehicle **10**, as shown at the right side of the display **44** in FIG. **14**. As shown in FIG. **14**, the simulated overhead view V_{C3} provides a simulated overhead view V_{C3} of the cargo area **26** and simulated overhead view of perceivable areas rearward of the rear end **20** of the vehicle **10**.

The simulated overhead view V_{C3} is generated in a manner consistent with the depiction in FIG. **16** of the overhead angle O_C which corresponds to the area viewed by the cargo area camera **60** with the tail gate open. In FIGS. **14** and **16**, the tailgate **36** is in the lowered or open position, thereby rendering the rear camera **54** inoperable.

The cargo area camera **60** provides many advantages. For example, since the rear camera **54** is installed to the tailgate **36**, the cargo area camera **60** can provide s substitute rear view of the vehicle **10** when the tailgate **36** is in the open position or removed completely from the vehicle **10**. Fur-

ther, the cargo area camera **60** is disposed on the vehicle body **16** at a location that facilitates convenient capturing of a view of the trailer hitch receiver **38** installed to the cargo area **26** such that the driver (the vehicle operator) viewing the display **44** observes the trailer hitch receiver **38** as the vehicle moves toward a trailer hitch of a trailer T, as depicted in FIG. **15**. The driver can view both the overhead simulated view V_{C3} and an unaltered view of the video images captured by the cargo area camera **60** while coupling the vehicle **10** to the trailer T.

Second Embodiment

Referring now to FIGS. **17** and **18**, a vehicle **10'** depicted in accordance with a second embodiment will now be explained. In view of the similarity between the first and second embodiments, the parts of the second embodiment that are identical to the parts of the first embodiment will be given the same reference numerals as the parts of the first embodiment. Moreover, the descriptions of the parts of the second embodiment that are identical to the parts of the first embodiment may be omitted for the sake of brevity. The parts of the second embodiment that differ from the parts of the first embodiment will be indicated with a single prime (').

In the second embodiment, the vehicle **10'** is a van that has a van structure. The vehicle **10'** includes a cargo area **26'** that defines an enclosed space **26c'** within the van structure of the vehicle **10'**. As shown in FIG. **18**, the cargo area **26'** includes a floor **26a'**, side walls **26b** and a roof (removed in FIG. **18**) that define the enclosed space **26c'** that is configured to receive cargo (not shown). The enclosed space **26c'** of the cargo area **26'** is defined between side walls **26a'** and above the floor **26b'** of the cargo area **26'**. The cargo area **26'** includes a cargo area camera **60** that is basically identical to the cargo area camera **60** of the first embodiment, but is positioned to view the enclosed space **26c'** of the cargo area **26'**. The vehicle **10'** includes a video system that is virtually identical to the video system **12** of the first embodiment as shown in FIG. **2**, including the front camera **52**, the rear camera **54**, the passenger's side camera **56** (not shown in FIGS. **17** and **18**), the driver's side camera **58** and the cargo area camera **60**. In the second embodiment, the rear camera **54** is located on one of two cargo area doors of the van structure of the vehicle **10'**. Further, as shown in FIG. **18**, the display **44'** in the second embodiment shows the interior of the cargo area **26'** on the left side of the display **44'** and shows the various simulated overhead views superimposed over a still image of the van structure of the vehicle **10'**.

The video system in the second embodiment operates in a manner identical to the video system **12** described with respect to FIGS. **2** and **10**. For example, the vehicle sensors **48** depicted in FIG. **2** can include a sensor that senses whether or not the rear cargo doors of the vehicle **10'** are closed. If the rear cargo doors are not closed (doors are open), the performance of the rear camera **54** may be compromised. As described above, the cargo area camera **60** can be used to capture video images of areas rearward of the vehicle **10'** as well as capture images of the cargo area **26'** when the rear cargo doors are open. This feature is the same as that described above with respect to FIGS. **2** and **10**.

Since all aspects of the video system described above with respect to the first embodiment are identical and operate in the same manner as in the first embodiment, further description is omitted for the sake of brevity.

Third Embodiment

Referring now to FIGS. **19** and **20**, a vehicle **10"** in accordance with a third embodiment will now be explained.

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In view of the similarity between the first and third embodiments, the parts of the third embodiment that are identical to the parts of the first embodiment will be given the same reference numerals as the parts of the first embodiment. Moreover, the descriptions of the parts of the third embodiment that are identical to the parts of the first embodiment may be omitted for the sake of brevity. The parts of the third embodiment that differ from the parts of the first embodiment will be indicated with a double prime (").

In the third embodiment, the video system 12 is identical to that of the first embodiment, except that the cargo area camera 60 is removed and replaced with two cargo area cameras 60". The cargo area cameras 60" are installed to the vehicle 10" at opposite rear end corners of the cabin structure and are both aimed at the cargo area 26 in order to capture video images of the cargo area. In the third embodiment, the image processor 50 is further configured to process the video images from the cargo area cameras 60" such that the simulated video overhead view of the cargo area is a composite image based upon the video images captured by the cargo area cameras 60". Further, in the event that one of the cargo area cameras 60" is blocked by cargo or another object, the image processor 50 can still generate the simulated video overhead view of the cargo area based primarily or solely on video images from a remaining unblocked one of the cargo area cameras 60".

The vehicles 10, 10' and 10" include various conventional components that are well known in the art. Since these conventional components are well known in the art, these structures will not be discussed or illustrated in detail herein. Rather, it will be apparent to those skilled in the art from this disclosure that the components can be any type of structure and/or programming that can be used to carry out the present invention.

General Interpretation of Terms

In understanding the scope of the present invention, the term "comprising" and its derivatives, as used herein, are intended to be open ended terms that specify the presence of the stated features, elements, components, groups, integers, and/or steps, but do not exclude the presence of other unstated features, elements, components, groups, integers and/or steps. The foregoing also applies to words having similar meanings such as the terms, "including", "having" and their derivatives. Also, the terms "part," "section," "portion," "member" or "element" when used in the singular can have the dual meaning of a single part or a plurality of parts. Also as used herein to describe the above embodiments, the following directional terms "forward", "rearward", "above", "downward", "vertical", "horizontal", "below" and "transverse" as well as any other similar directional terms refer to those directions of a vehicle equipped with the vehicle video system. Accordingly, these terms, as utilized to describe the present invention should be interpreted relative to a vehicle equipped with the vehicle video system.

The term "detect" as used herein to describe an operation or function carried out by a component, a section, a device or the like includes a component, a section, a device or the like that does not require physical detection, but rather includes determining, measuring, modeling, predicting or computing or the like to carry out the operation or function.

The term "configured" as used herein to describe a component, section or part of a device includes hardware and/or software that is constructed and/or programmed to carry out the desired function.

The terms of degree such as "substantially", "about" and "approximately" as used herein mean a reasonable amount of deviation of the modified term such that the end result is not significantly changed.

While only selected embodiments have been chosen to illustrate the present invention, it will be apparent to those skilled in the art from this disclosure that various changes and modifications can be made herein without departing from the scope of the invention as defined in the appended claims. For example, the size, shape, location or orientation of the various components can be changed as needed and/or desired. Components that are shown directly connected or contacting each other can have intermediate structures disposed between them. The functions of one element can be performed by two, and vice versa. The structures and functions of one embodiment can be adopted in another embodiment. It is not necessary for all advantages to be present in a particular embodiment at the same time. Every feature which is unique from the prior art, alone or in combination with other features, also should be considered a separate description of further inventions by the applicant, including the structural and/or functional concepts embodied by such features. Thus, the foregoing descriptions of the embodiments according to the present invention are provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

What is claimed is:

1. A method for capturing and displaying images, the method comprising:
    fixedly attaching a first video camera to a vehicle at a first fixed location in a prescribed orientation aimed to capture images of a cargo area defined within a vehicle body structure of a vehicle;
    providing an electronic display within the vehicle;
    capturing video images of the cargo area using the first video camera;
    processing the video images of the cargo area captured by the first video camera and generating a simulated video overhead view of the cargo area; and
    displaying on the electronic display a still image representing an overhead view of the vehicle, and superimposing on the display over an area of the still image corresponding to the location of the cargo area the generated simulated video overhead view of the cargo area.

2. The method for capturing and displaying images according to claim 1, wherein
    the fixedly attaching of the first video camera includes the first fixed location being a rearward exterior surface of a cabin structure of a pickup truck adjacent to the cargo area of the pickup truck.

3. The method for capturing and displaying images according to claim 1, wherein
    the displaying on the electronic display includes switching between displaying the simulated video overhead view of the cargo area over the still image of the vehicle on the electronic display and displaying the actual video images of the cargo area captured by the first video camera on the electronic display without of the still image of the vehicle.

4. The method for capturing and displaying images according to claim 1, wherein
    the fixedly attaching of the first video camera includes aiming the first video camera to also capture images of an area rearward of the vehicle adjacent to the cargo area,

the processing of the video images includes generating a simulated video overhead view of the area rearward of the vehicle, and

the displaying on the electronic display includes displaying of the simulated overhead view of the area rearward of the vehicle over an area adjacent to a rearward area of the still image of the vehicle.

5. The method for capturing and displaying images according to claim 4, wherein

the displaying on the electronic display includes switching between displaying the simulated video overhead view of the cargo area over the still image of the vehicle on the electronic display with the simulated overhead view of the area rearward of the vehicle, and displaying the actual video images of the cargo area and the area rearward of the vehicle captured by the first video camera on the electronic display without of the still image of the vehicle.

6. The method for capturing and displaying images according to claim 1, wherein

the fixedly attaching of the first video camera includes fixedly attaching a plurality of additional video cameras to mutually differing prescribed locations around an outer periphery of the vehicle in prescribed orientations providing respective video images of areas around the outer periphery of the vehicle, and

the processing of the video images includes processing video images captured by each of the plurality of additional video cameras, generate further simulated overhead views of the prescribed locations around the outer periphery of the vehicle, and

the displaying on the electronic display includes superimposing the further simulated overhead views to corresponding areas around the still image of the vehicle on the display.

7. The method for capturing and displaying images according to claim 6, wherein

the displaying on the electronic display includes switching between displaying the simulated video overhead views, and displaying the actual video captured by the first video camera and the plurality of additional video cameras on the electronic display without of the still image of the vehicle.

8. The method for capturing and displaying images according to claim 1, wherein

the fixedly attaching of the first video camera includes the first fixed location being an interior surface an enclosed cargo structure, the enclosed cargo structure including a floor, upright walls and a roof structure defining the cargo area, with the interior surface being one of the upright walls of the enclosed cargo structure.

9. The method for capturing and displaying images according to claim 1, wherein

the fixedly attaching of the first video camera includes fixedly attaching a second video camera to the vehicle at a second prescribed location spaced from the first prescribed location to capture an additional video image of the cargo area.

10. The method for capturing and displaying images according to claim 9, wherein

the processing of the video images includes processing the video image from the first video camera and the video image of the second video camera such that the simulated video overhead view is a composite image based upon the video images captured the first and second video cameras.

11. The method for capturing and displaying images according to claim 1, wherein

the fixedly attaching of the first video camera includes aiming the first video camera to further capture a view of a trailer hitch receiver installed to the cargo area such that a vehicle operator viewing the electronic display observes the trailer hitch receiver as the vehicle moves toward a trailer hitch of a trailer.

12. The method for capturing and displaying images according to claim 1, wherein

the processing the video images includes determined a location of a movable member mounted to a rear portion of the vehicle for movement between a first position and a second position such that in the first position, the movable member blocks the first video camera from capturing a video image of the an area rear of the vehicle, and in the second position the movable member does not block the first video camera from capturing a video image of the an area rear of the vehicle,

the fixedly attaching of the first video camera includes attaching a second video camera to the movable member such that with the movable member in the first position, the second video camera is positioned at a second fixed location in a prescribed orientation relative to the vehicle to capture a video image of the area rear of the vehicle, and with the movable member in the second position, the second video camera is obscured.

13. The method for capturing and displaying images according to claim 1, wherein

the fixedly attaching of the first video camera includes fixedly mounting a plurality of additional video cameras to mutually differing prescribed locations around an outer periphery of the vehicle in prescribed orientations providing respective video images of areas around the outer periphery of the vehicle, the plurality of additional video cameras including a front video camera fixed to a front portion of the vehicle, a rear video camera fixed to a rear portion of the vehicle and a pair of side video cameras fixed to opposite sides of the vehicle, and

the processing the video images includes process the video images captured by each of the plurality of additional video cameras to generate further simulated overhead views of the prescribed locations around the outer periphery of the vehicle, and

the displaying on the electronic display includes superimposing the further simulated overhead views to corresponding areas around the still image of the vehicle on the display such that the simulated video overhead view shows at least the portion of the cargo area, an area in front of the vehicle, an area behind the vehicle and areas along each side of the vehicle superimposed over a still image of the vehicle.

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